of this kind at some former stage in the earth's history. It is impossible here to summarise the discussion, which is somewhat intricate, but Prof. Love's verdict—and there can be no better authority—is, on the whole, unfavourable to the suggestion.

The concluding sections of the book deal with the propagation of seismic waves. This is at the present time a question of the highest interest. Instruments have been greatly improved, and the records make an increasing claim to be regarded as faithful transcripts of the earth-movements. Phases more or less conspicuous are recognised in the diagrams, and are successfully used for the location of distant centres of disturbance. But the details of the records, and in particular the predominance, at different stages, of oscillations of various periods, offer much that is perplexing. For instance, it is difficult to account for the resolution of a transient shock, as it proceeds, into a series of oscillations of gradually changing period except on the hypothesis of something analogous to "dispersion" in optics, the essence of which is a variation of wave-velocity with wavelength. General elastic theory, on the other hand, suggests constant wave-velocities, whether in the case of the longitudinal and transverse vibrations, which are supposed to be propagated through the body of the earth, and to constitute the first and second phases of an earthquake disturbance, or in that of the larger "Rayleigh" waves, which travel over the surface. This theory, however, takes no account of gravity, or of variation of density and elastic properties with depth. Prof. Love has no difficulty in showing that when such circumstances are taken into consideration some amount of "dispersion" must ensue.

There is another particular in which the general theory appears to be inadequate. When the larger waves set in at any place, the horizontal displacement of the ground may at first be partly or even mainly transverse to the direction of propagation, whereas in the "Rayleigh" type of waves the horizontal component is longitudinal. Prof. Love meets this difficulty by the hypothesis that the earth consists of a comparatively thin crust, resting on a core which is denser and of different elastic properties. In this way it is possible to reconcile the fact of transverse displacement with (practically) superficial propagation; moreover, dispersion, almost as a matter of course, makes its appearance. We believe that this theory is worthy of careful examination; but much remains to be done in the way of quantitative as well as qualitative comparison with actual seismograms, before any decisive verdict can be passed upon it.

It will be seen from the above rapid outline that the work under review deals with problems of great difficulty, but of the utmost interest, in a rapidly developing branch of science. It is needless to say that they are treated with great mathematical skill. The book received, indeed, the Adams Prize for the year 1911. This prize is remarkable, even among similar foundations, for the high quality of the work which it has called forth. Many of the treatises thus produced, *e.g.*, Maxwell's essay on Saturn's rings and Routh's on stability of motion, not to mention others by living authors, have become classics. It is no slight praise to say that Prof. Love's work is worthy of the distinguished company in which it finds itself.

H. L.

ELECTRICAL ENGINEERING.

The Elements of Electrical Transmission. A Text-book for Colleges and Technical Schools. By Prof. O. J. Ferguson. Pp. vii + 457. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1911.) Price 15s. net.

Direct and Alternating Current Manual. With Directions for Testing, and a Discussion of the Theory of Electrical Apparatus. By Prof. F. Bedell. Assisted by Dr. Clarence A. Pierce. Second Edition, enlarged and revised. Pp. xiii + 360. (London: Constable and Co., Ltd., 1912.) Price 8*s.* net.

Storage Batteries. The Chemistry and Physics of the Lead Accumulator. By Prof. H. W. Morse. Pp. v + 266. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1912.) Price 6*s.* 6*d.* net.

Maschinen und Apparate der Starkstromtechnik: ihre Wirkungsweise und Konstruktion. Erster Teil: "Gleichstrom." Zweiter Teil: "Wechselstrom." By Gustav W. Meyer. Pp. xiv + 590. (Leipzig and Berlin: B. G. Teubner, 1912.) Price 15 marks.

"ELECTRICAL Transmission" covers a somewhat wider field than indicated by the title, for the author has included also some notes on hydraulics, water and steam turbines, Diesel engines, boilers, working cost of prime movers, switch-boards, transformers, induction, synchronous and commutator motors, measuring instruments, and other matters pertaining to the use and sale of electricity after it has been transmitted. In treatment the book is thoroughly practical, although, as may be expected, American practice predominates. This is no drawback, since for high voltage long-distance transmission English readers cannot do better than study the details of the work done in America, but there are also some features in English and Continental practice which are worthy of study and should therefore not be omitted in a handbook on the subject. Thus the Merz-Price safety device, which has made the linking-up of the power-stations on the north-east coast possible, and is now also extensively used on the Continent, is not even mentioned, the subject of graded cables is dismissed with a few lines, there is no mention of Nagel's condenser bushings, and the hexagonal arrangement of duplicated power lines, now almost universal in Switzerland, is also ignored.

Another rather serious omission is that of the Thury D.C. system of transmission. This has been in successful operation on the Continent for many years at voltages exceeding 100,000, and it has quite recently been taken up by Mr. Highfield in England. Some of the information as to conductors might have been given in a more scientific way. Thus the "breaking weight" for hard and annealed copper wire is given in pounds with reference to the B and S gauge. It is also to be regretted that the author has not emancipated himself from the unit called the "circular mil." There is no difficulty in expressing the area of a wire in square inches, or square mils if a smaller unit is desired, but to use the C.M. is unscientific and confusing.

The constants of a transmission line are treated in a clear manner, and the transition from the single to the polyphase circuit is made in an easy and natural way, the mathematics employed being throughout of an elementary kind and easy to follow. Unfortunately the author lets his vectors rotate clockwise, which must be a little irksome to those readers who have, in conformity with the decision of the Turin Congress, accustomed themselves to think of vectors revolving counter-clockwise.

In "Direct and Alternating Current Manual" we have a second and improved edition of a book which appeared three years ago under the title, "Direct and Alternating Current Testing." Although the book is primarily concerned with the testing of machinery, it does not simply give instruction how such tests should be made, but it also gives digests of the theory of the machines themselves. The only exception to this is the chapter on wave analysis, where Runge's method for eighteen known ordinates is given without proof. The instruction is, however, so clear and exemplified by a numerical example that the reader cannot fail to apply the method correctly.

Two chapters only are devoted to D.C. machine tests. There we find some of the well-known methods described, but the statement on page 46 that in a shunt motor the iron losses are independent of the load will scarce be confirmed by engineers who have made such tests carefully. Chapter iii. treats of alternators, and especially of the relation between excitation and terminal voltage. We are told about the "optimistic" and "pessimistic" methods of determining drop, but these favourite expressions of American writers do not carry us very far in separating the two causes, namely, inductance and armature ampere turns, which combined produce the drop. This chapter is rather disappointing. It is also somewhat tiresome that throughout the book the authors use copious foot-notes, sometimes in correction of a statement made in the text. The general properties of alternating current circuits and transformer tests are treated in Chapters iv. and v., but the treatment is rather elementary and does not include some important tests, such, for instance, as heating and efficiency of large transformers. We are merely told on page 177 that a heat run is "usually made by some kind of opposition or pumping back method, of which there are several." Then follows a general description of one such method, but as no diagram of connections is given, the few lines of text will not be of much use to the student.

The following chapters, dealing with polyphase currents, are more satisfactory, especially the analysis of the effect of upper harmonics in star and mesh three-phase systems and power and power factor measurements. Next follow chapters on the induction motor and the circle diagram, frequency changers, synchronous motors, but the single-phase commutator motor is not discussed.

"Storage Batteries" is an unpretentious, but very attractively written little volume. In discussing the general principles of chemical storage of energy the author starts from Faraday's laws of electrolysis and takes the reader by easy stages to the predetermination of the E.M.F. of any combination, to the ionic theory, the cell-reaction, and finally to the theory of the reversible lead accumulator. When dealing with the relation between discharge rate and capacity, the author makes use of Peukert's formula $I^n t = \text{constant}$ (though without acknowledgment), and gives a very instructive series of curves, showing how the exponent varies in different types of cells. Examples are also given of some commercial types of cells, and amongst these it is interesting to find the Edison cell, about which so much has been written and so little is known.

The last book on the above list is an exhaustive treatise on apparatus and machinery concerned with heavy electrical engineering. The book will be found useful not only by students, but even more so by men in practical work. The author is not content to give the theory of machines, their mode of working, and the principles underlying the construction, but he gives the actual construction by working drawings and excellent pictures and detailed instruction required in the workshop.

The space available for this review does not permit of an enumeration of the contents in detail; it must therefore suffice merely to mention the main headings. The first three chapters deal with continuous current. We find here measuring instruments, switchgear, rheostats, accumulators, D.C. machines, special types of motors as used on railways and for winding engines, speed control, and the use of D.C. apparatus generally. The rest of the book is taken up with A.C. work. Here, again, we start with measurement and the construction of measuring instruments, then follow switchgear and safety appliances, the construction and testing of generators, parallel working, converters, transformers, synchronous and asynchronous motors, starting and regulating devices, and finally commutator motors. It is an excellent book and will be found useful by all practical men who work on scientific principles. Gisbert Kapp.

PRINCIPIA MATHEMATICA.

Principia Mathematica. By Dr. A. N. Whitehead, F.R.S., and Bertrand Russell, F.R.S. Volume ii. Pp. xxxiv + 772. (Cambridge: The University Press, 1912.) Price 30*s.* net.

THE main features of this important work have been described in a previous notice (August 31, 1911, p. 273). In the present volume the authors come more directly into contact with what may be called traditional arithmetic and algebra, the three parts being devoted to cardinal arithmetic, relation-arithmetic, and series respectively. Our old familiar friend, the family of natural numbers, appears under the head of "inductive cardinals"; besides this, and preceding it, we have a discussion of various types of cardinals, definitions of addition, multiplication, and exponentiation valid for transfinite, as well as finite, numbers; thence we proceed to the study of intervals, progressions, the first transfinite cardinal, and the axiom of infinity.

The section on relational arithmetic almost brings us back to formal logic again; it is a sort of analogue to ordinal arithmetic, and, as the authors point out, it is in the present context mainly important as a preparation for the doctrine of series, which immediately follows. The mathematical reader will be struck by the fact that a relation which generates a series is analysed into one which possesses three separate and independent properties. Important technical terms here are "section" and "segment" (pp. 624 *et seq.*), and in all this connection the contributions of Dedekind and Cantor make themselves felt. The final section brings us to the general problems of convergence, limit, and continuity; and the reader who has the courage to learn the new symbolism will now find that there has been a real philosophical advance in the period between Cauchy and Cantor; or perhaps it would be better to say that Cantor has initiated a new era of research, so far as any one man is truly an initiator.

Analogies are always dangerous, and in nothing more so than in pure mathematics; but one cannot help feeling that all this recent investigation of the elements of mathematics has some affinity to the chemical analysis of molecules into their atoms. Perhaps it may not be absurd to carry the metaphor a little further. Electricians have proved that the atom of the chemist is a much more complicated entity than he imagined; it is possible that the present irreducibles of the mathematician may dissociate, if subjected to still severer tests. If this be so, the resolver will be either a mathematician or a metaphysician, or a combination of both; and even he may not (indeed, probably will not) arrive at ultimate conclusions with which the human spirit will rest content.

It would be very unfair not to point out that the authors, by immense and ungrudging work, have fused together the discoveries of many searchers (including themselves) into as near a homogeneous whole as present circumstances permit. G. B. M.

DISEASE-DISSEMINATING ARTHROPODS.

Entomology for Medical Officers. By A. Alcock, C.I.E., F.R.S. Pp. xx + 347 + 136 text-illustrations. (London: Gurney and Jackson, 1911.) Price 9*s.* net.

IT has well been said that tropical medicine is nowadays largely a matter of entomology, and it is to the recognition of this fact that the volume before us owes not only its appearance, but also much of the knowledge epitomised in its pages. The term "entomology" is interpreted by the author in the "old inclusive Latreillian sense," and we consequently find ourselves concerned not merely with insects, but with the Arthropoda as a whole, or rather with those groups of this enormous phylum with which the medical officer in the tropics at the present day must needs have a nodding acquaintance or something more.

In view of the transcendent importance of the Diptera in connection with disease, it is not surprising to find that nearly half of the volume is